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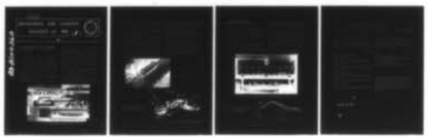

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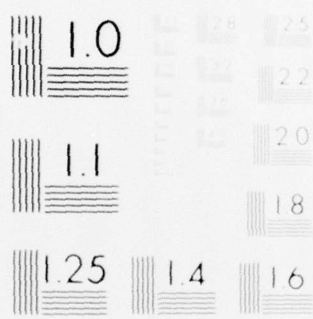

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ENGINEERING AND SCIENTIFIC RESEARCH AT WES

Miscellaneous Paper O-73-5 April 1973

EXTRATERRESTRIAL GROUND MOBILITY,

by K.-J. Melzer, Mobility and Environmental Systems Laboratory

Ground mobility research took an "upward" turn in 1969 and literally went into orbit when the National Aeronautics and Space Administration (NASA) asked the Waterways Experiment Station (WES) to evaluate proposed wheel concepts for the Lunar Roving Vehicle (LRV). After an extensive program of testing and evaluation, WES recommended the selection of the wheel that was successfully used on the LRV during Apollo 15 and subsequent Apollo missions. Not only did the wheels perform as predicted, but the slopes climbable by the LRV and the distance it could travel on the lunar surface also were accurately predicted.

It was not surprising, then, that in 1970 NASA asked WES to test and evaluate a new running gear for possible use on extraterrestrial vehicles: an Elastic Loop Mobility System (ELMS). The ELMS, developed by Lockheed Missiles and Space Company under a NASA contract, combines the major advantages of wheeled vehicles, such as mechanical simplicity, reliability, and low internal losses, with the advantages of tracked vehicles, that is, reduced and more uniform ground contact pressure, resulting in improved soft-soil performance and superior obstacle negotiation.

The first-generation ELMS was tested at WES in 1970-71. An improved second-generation version was delivered to WES in 1972, and its mobility performance has been extensively evaluated.

The performance of the ELMS on soft soil was tested in a single-unit dynamometer system (fig. 1) on a lunar soil simulant at strength levels that allowed a comparison

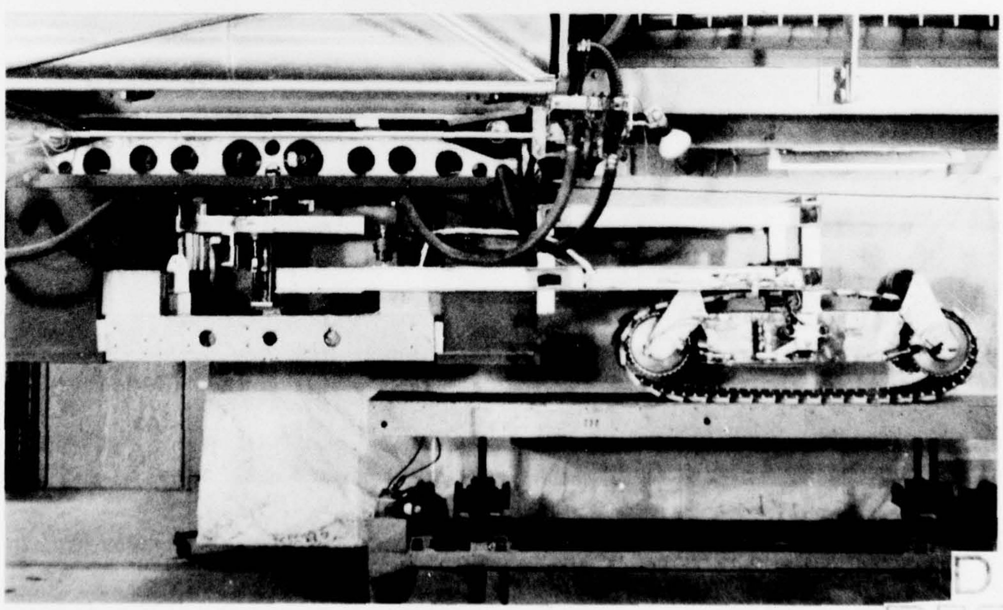

Fig. 1. ELMS in WES dynamometer system

with the performance of the LRV wheels. Instrumentation provided for continuous recording of load, pull, torque, pitch moments, damping energies, speeds, and slip. Test loads were 565 and 690 newtons, which correspond approximately to the loads under which the ELMS would operate in the gravitational field on Mars. Vehicle speeds were varied from about 0.2 to 2.0 m/sec.

Slope-climbing capability of the ELMS also was investigated. For this purpose, a trailer was attached to the ELMS to stabilize it (fig. 2), and a test bin in which soil had been prepared to the desired consistency was tilted to the angle at which the ELMS was to be tested. The ropes shown in fig. 2 were used to counterbalance the effect of the trailer weight component parallel to the slope. Instrumentation provided for recording the same variables measured during the dynamometer tests on level test lanes, except load. The maximum slope that the ELMS climbed was 35 deg, which was the largest angle that could be achieved by tilting the test bin. There were indications that the system could climb slopes up to 38 deg. Basically, it was determined that the slope-climbing capability can be predicted from results of tests on level surfaces.

In a third phase of the evaluation program, the ELMS-trailer combination was run over one-step, rigid, discrete obstacles and across simulated crevasses. The vehicle combination negotiated obstacles up to 46 cm high and crossed crevasses up to 100 cm wide.

The test results indicate that the ELMS performance was better than that of other mobility systems, for example the LRV wheel. Its mechanical simplicity and reliability are extremely important factors, especially in extraterrestrial operations. Furthermore, several units can be joined to comprise an "overland" train (fig. 3).

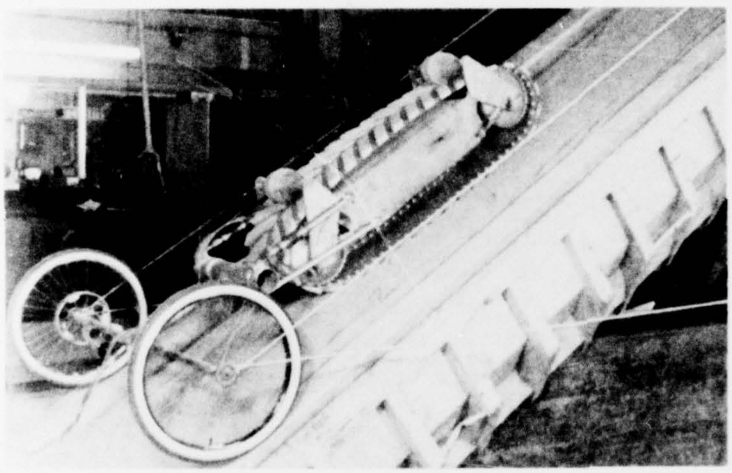

Fig. 2. ELMS climbing 34-deg slope

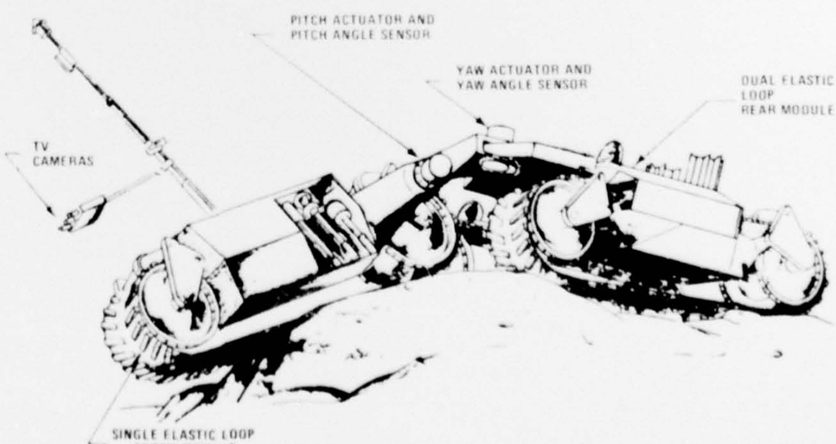

Fig. 3. Artist's concept of unmanned roving vehicle made up of a front ELMS unit and dual rear units

(Courtesy of Lockheed Missiles & Space Company)

SEEPAGE IN EARTH BANKS,

by C. S. Desai, Soils and Pavements Laboratory

Determination of the time-dependent movements of the free surface caused by transient changes in the external fluid levels becomes essential for precise analyses of such structures as riverbanks and dams. Complexities arise due to nonlinear laws governing the movements of the free surface, arbitrary geometries of banks, and nonhomogeneities.

Experimental and analytical investigations have been performed by the Waterways Experiment Station (WES) to evolve better design procedures for stability analyses of such structures. The investigations have been aimed specifically at the design of protective revetments for the banks of the Mississippi River and have been sponsored by the U. S. Army Engineer Division, Lower Mississippi Valley.

A large parallel-plate viscous flow model (fig. 1) was constructed in the WES soils laboratory to simulate rise and fall (drawdown) in the river level. Piezometers were installed at a number of locations along the river to obtain field measurements of fluid heads in the banks as the river level changed (fig. 2). Numerical procedures based on the finite difference and the finite element methods have been developed. The finite element (fig. 3) procedure involved computer codes based on bilinear, quadratic, and cubic approximating models with isoparametric elements.

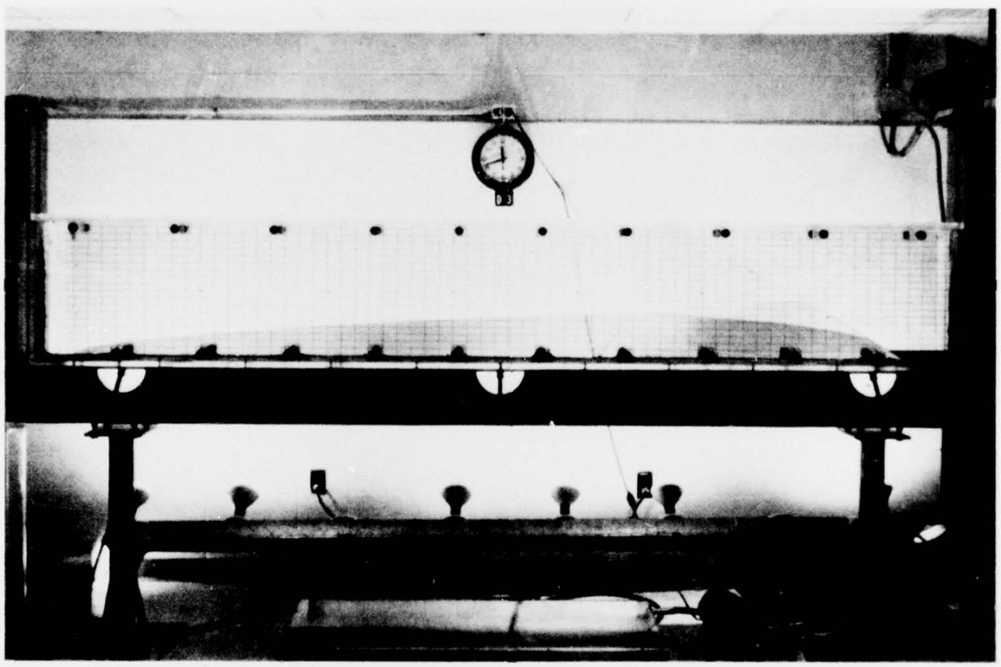

Fig. 1. Free surface during drawdown in parallel-plate model

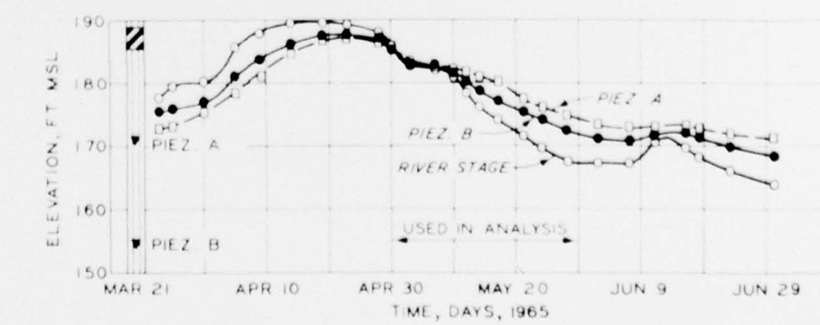

Fig. 2. Variations in heads and river level at a typical section along the Mississippi River

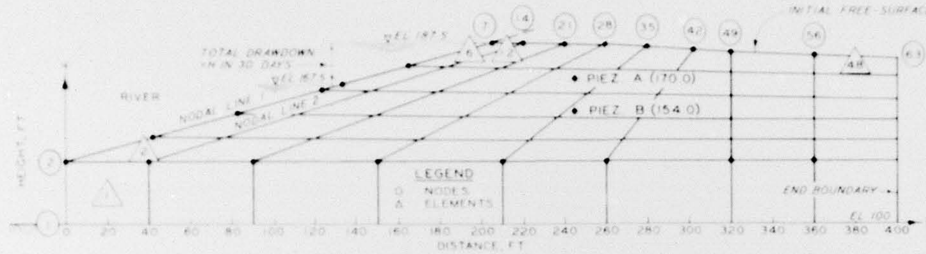

Fig. 3. Finite element mesh for typical section

Trade-offs in cost and accuracy with respect to the use of higher order models are being considered. Also being considered are such numerical aspects as convergence and stability of the procedures. A self-generating scheme to adopt the size of the time increment consistent with convergence and numerical stability has been developed.

The numerical finite difference and finite element solutions and the laboratory and field data have shown satisfactory correlation. Efforts toward evolving charts for design analysis are in progress.

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REPORTS RECENTLY PUBLISHED BY WES

Concrete Laboratory:

Ultimate Strain Capacity Tests, Clarence Cannon Dam, St. Louis District, by J. E. McDonald, Miscellaneous Paper C-73-5, Mar 1973.

Hydraulics Laboratory:

Mathematical Simulation of the Turbidity Structure Within an Impoundment; Hydraulic Laboratory Investigation, by D. H. Fontane, J. P. Bohan, and J. L. Grace, Jr., Research Report H-73-2, Mar 1973.

Soils and Pavements Laboratory:

Study of Behavior of Bituminous-Stabilized Pavement Layers, by C. D. Burns, R. H. Ledbetter, and R. W. Grau, Miscellaneous Paper S-73-4, Mar 1973.

Rapid Road Construction using Membrane-Enveloped Soil Layers, by A. H. Joseph, R. D. Jackson, and S. L. Webster, Miscellaneous Paper S-73-5, Feb 1973.

Weapons Effects Laboratory:

Fundamental Experiments in Ground Shock Phenomenology, by J. G. Wallace and Jack Fowler, Miscellaneous Paper N-73-2, Mar 1973.

Automatic Data Processing Center:

Numerical Solution of Differential Equations, by S. I. Kang and J. B. Cheek, Jr., Miscellaneous Paper K-72-1, Aug 1972.

Explosive Excavation Research Laboratory:

Cratering in Layered Media, by A. S. Vesic, N. M. F. Ismael, and K. Bhushan, Technical Report E-72-31, Dec 1972.

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